

CDF Liverpool Group

Beate Heinemann

- People
- Service work
 - Silimon
 - Computing
 - Trigmon/XMON
- Physics: present
 - B-physics
 - QCD
 - Electroweak
 - New physics
- Future
 - Physics and FTE's



CDF UK meeting, 27th of February 2006

People

■ Lecturers and Advanced/RS Fellows:

- Michael Houlden
- Tara Shears
- Andy Mehta
- Rolf Oldeman
- Beate Heinemann
- B. King

■ Postdocs/postdoc fellows

- Tracey Berry
- Giulia Manca
- Sinead Farrington

■ Visitor:

- Ronan McNulty (UCD)

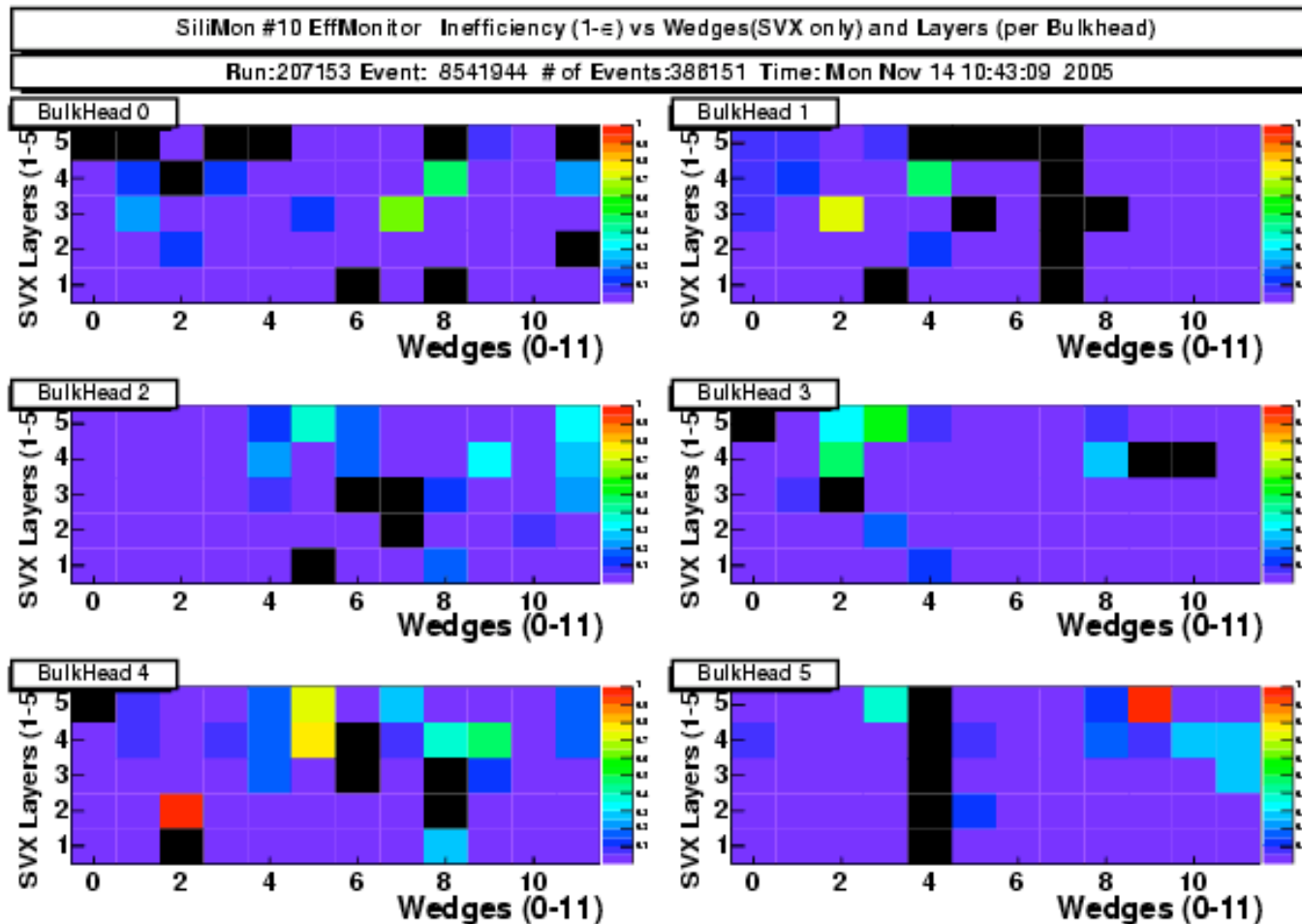
■ Students:

- Helen Hayward
 - done
- Anant Gajjar
 - done
- Martin Griffith
 - submit next month
- Sara-Madge Wynne
 - Ends in October
- Nick Austin
 - Just started

Responsibilities

- **Sinead Farrington:**
 - Convener of Mixing and Lifetime subgroup
 - Offline operations manager
- **Beate Heinemann**
 - Analysis Coordinator
 - Exotics Convener (until 12/05)
 - Jet Convener (until 05/04)
 - Spokes election committee (03/04 and 04/05)
 - Member of P5 task force
- **Andy Mehta:**
 - Convener: jet energy and resolution group
- **Tara Shears:**
 - Convener: photon group (until 12/05)

SiliMon



- Runs in Control Room (G. Manca, T. Shears)

Computing

- MAP2 PC farm:
 - 940 3GHz processors

T. Berry, S. Farrington,
M. George, M. Houlden

- For CDF

- 2 racks = 240 GHz

- Status of installation:

- SAM station setup complete

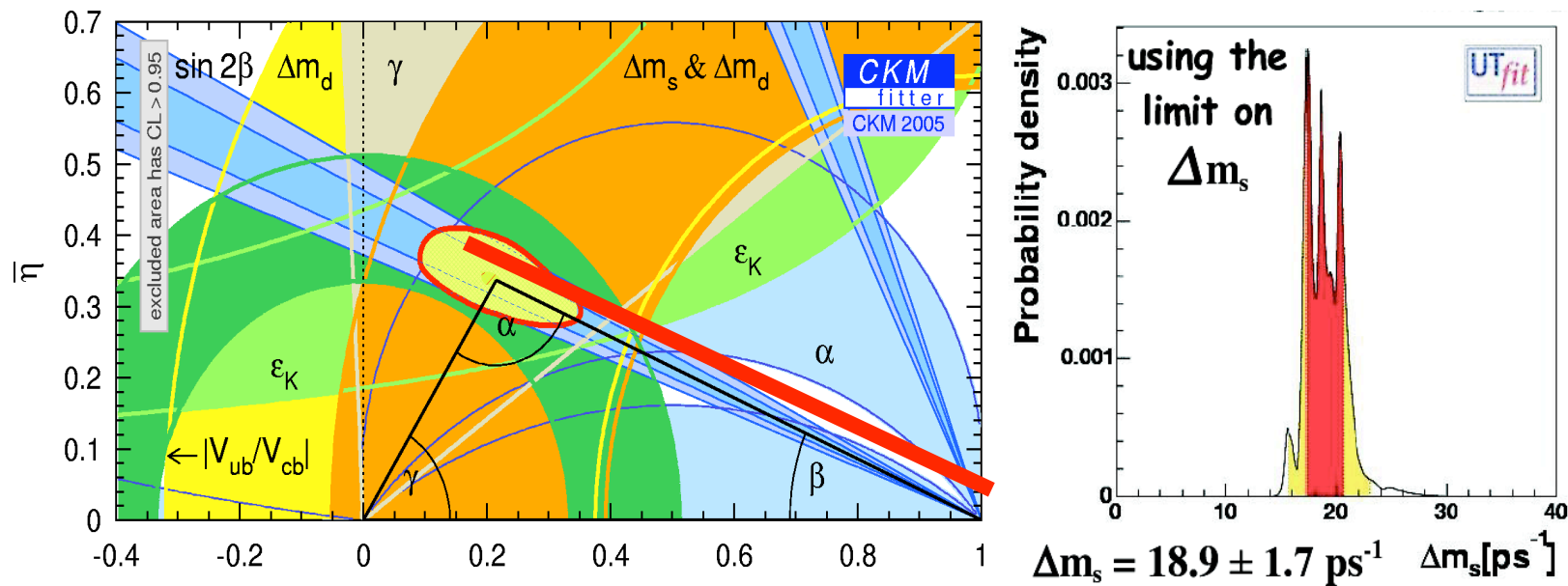
- dCAF installation ongoing:

- Can submit jobs to FNAL already
 - Michael George is coming to FNAL in one week
 - Will finish dCAF installation then
 - possibly try GlideCaf also => get more resources from ATLAS etc.

B physics

- Bs mixing
 - Sinead Farrington
- Rare decays
 - Sinead Farrington, Rold Oldeman
- $X_b \rightarrow \mu\mu$ (sister of X_c)
 - Rolf Oldeman

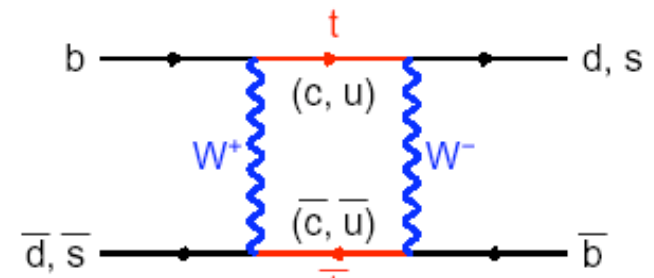
$B_s - \bar{B}_s$ mixing: Motivation



■ Measure side of unitarity triangle:

$$\Delta m_d / \Delta m_s$$

- CKM fit: $\Delta m_s = 18.9 \pm 1.7 \text{ ps}^{-1}$
- Observation will significantly shrink allowed region

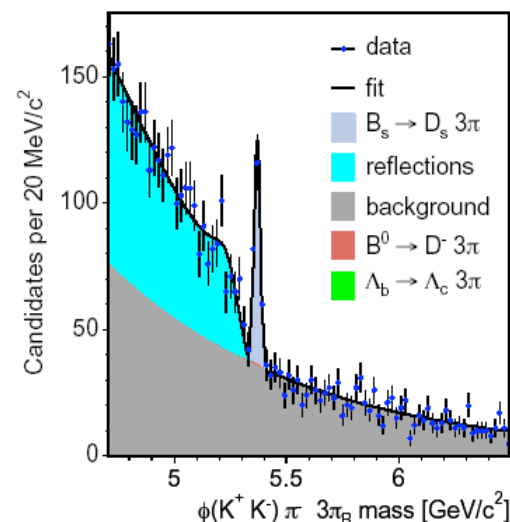


$B_s - \bar{B}_s$ mixing

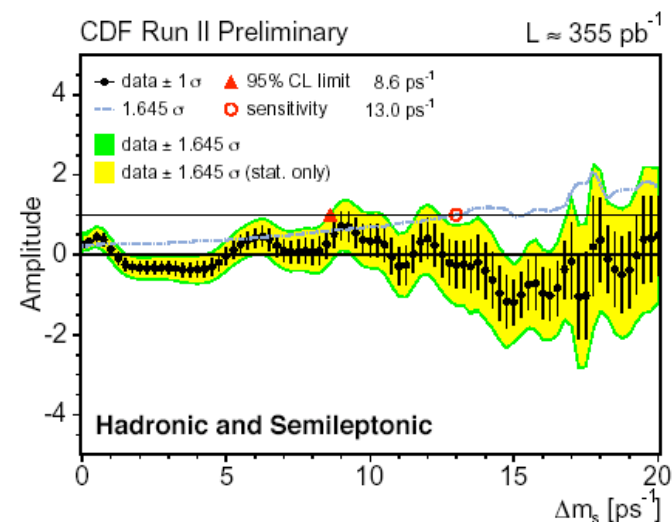
S. Farrington

- Measurement relies on:
 - Good vertex resolution (Layer00)
 - Reconstruction of B_s decay modes
 - Flavour of b at production: εD^2
- Latest CDF result:
 - Observed: $\Delta m_s > 8.6 \text{ ps}^{-1}$
 - Sensitivity: $\Delta m_s > 13.0 \text{ ps}^{-1}$
- Sinead worked on physics background
- Expect evidence this summer:
 - SSKT just got blessed!

$\chi^2 / \text{NDF} = 64.37 / 66$, Prob = 53.40%, K-Prob = 100.00%



$B_s \rightarrow D_s 3\pi$ $D_s^- \rightarrow \phi \pi$



Search for FCNC

- FCNC processes can be enhanced BSM:

- E.g. $b \rightarrow s \gamma^*$

- Search for:

- $B^+ \rightarrow \mu\mu K^+$ (observed at Belle/BaBar)
 - $B \rightarrow \mu\mu K^*$ (observed at Belle/BaBar)
 - $B_s \rightarrow \mu\mu \phi$
 - ♣ predicted $BR(B_s \rightarrow \mu\mu \phi) = 16.1 \times 10^{-7}$

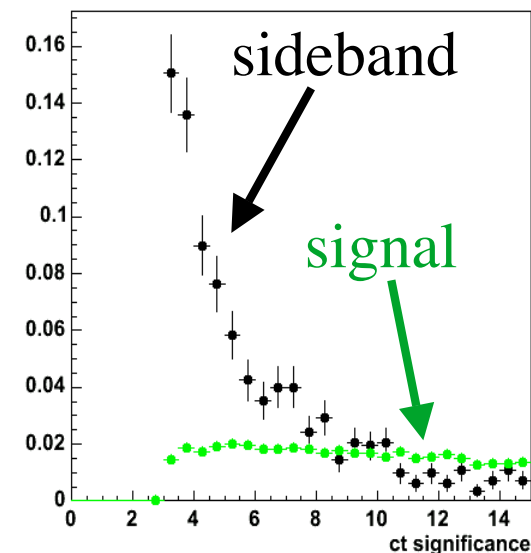
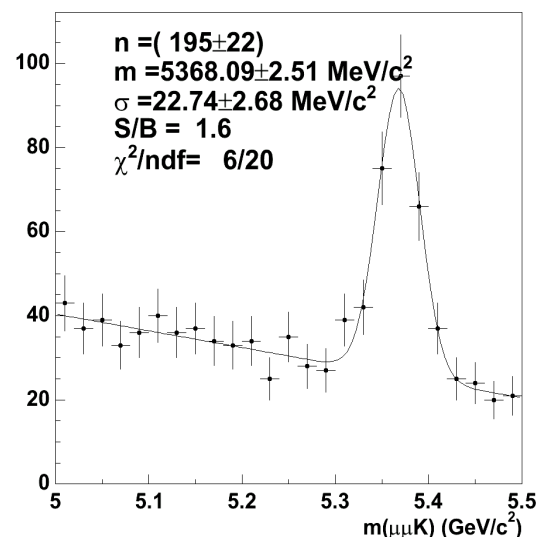
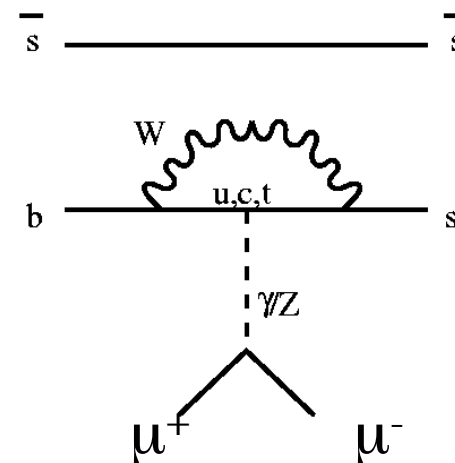
- Analysis blind:

- Control modes analysed:

- $B^+ \rightarrow J/\psi K^+ \rightarrow \mu\mu K^+$
 - $B^+ \rightarrow J/\psi K^* \rightarrow \mu\mu K^*$
 - $B^+ \rightarrow J/\psi \phi \rightarrow \mu\mu \phi$

- Cut optimisation ongoing

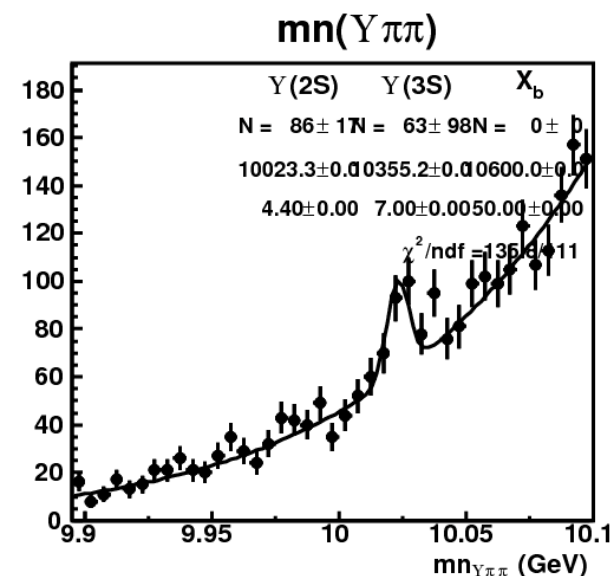
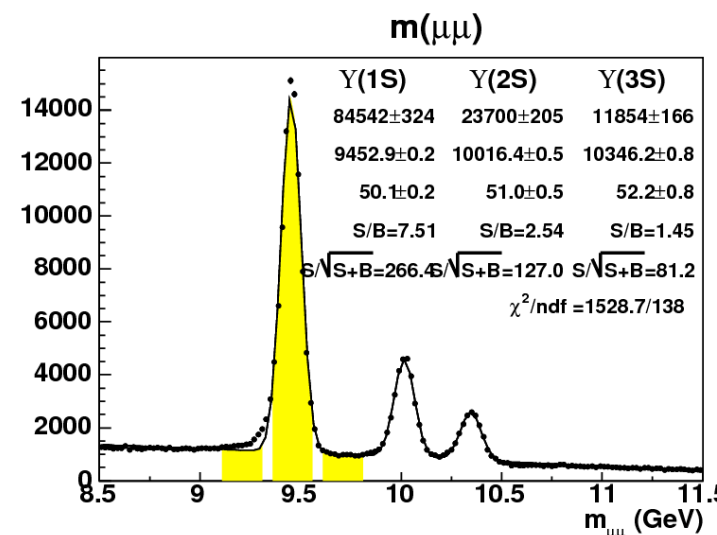
- Hoping for 3σ evidence for $BR(B_s \rightarrow \mu\mu \phi)$ with luminosity of 1 fb^{-1}



Search for $X_b \rightarrow Y(1S)\pi^+\pi^-$

S. Hewitt, R. Oldeman

- In 2003 Belle, CDF, D0, Babar discovered:
 - $X(3872) \rightarrow J/\psi \pi^+\pi^-$
 - ♣ Lot's of activity on understanding its nature:
 - ♣ 100+ citations for CDF paper alone
- Analogous $X_b \rightarrow Y(1S)\pi^+\pi^-$ predicted at 10.4-10.8 GeV
 - Reference signal $Y(2S) \rightarrow Y(1S)\pi^+\pi^-$
 - 85K upsilons in 860 pb⁻¹ of data
 - Reference signal: 86 +/- 17 events
- 5 σ sensitivity if $\approx 5\%$ of Y come from $X_b \rightarrow Y(1S)\pi^+\pi^-$
 - ♣ Unknown *a priori*
 - ♣ Will open "blind box" soon



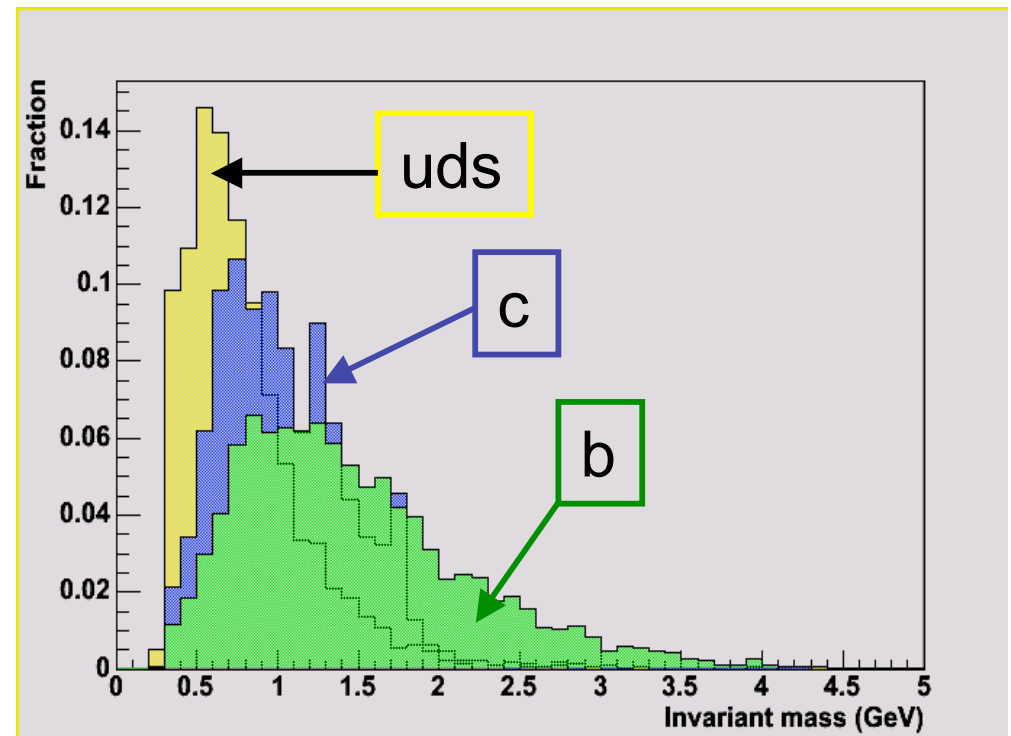
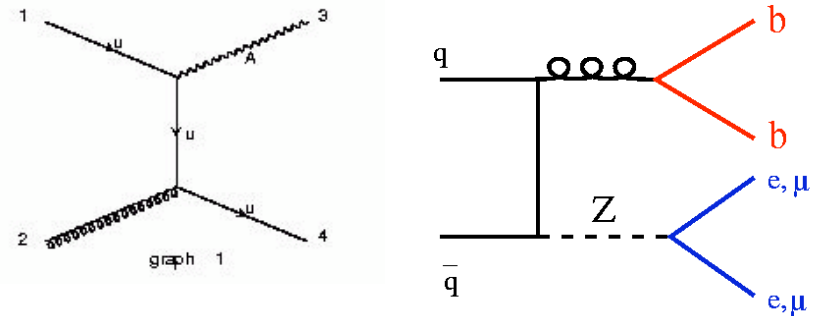
QCD physics

- Bbbar production:
 - Anant Gajjar, R. McNulty, T. Shears
- Photon+b/c:
 - Tara Shears
- Z+b
 - Andy Mehta, BH

B-jet Production

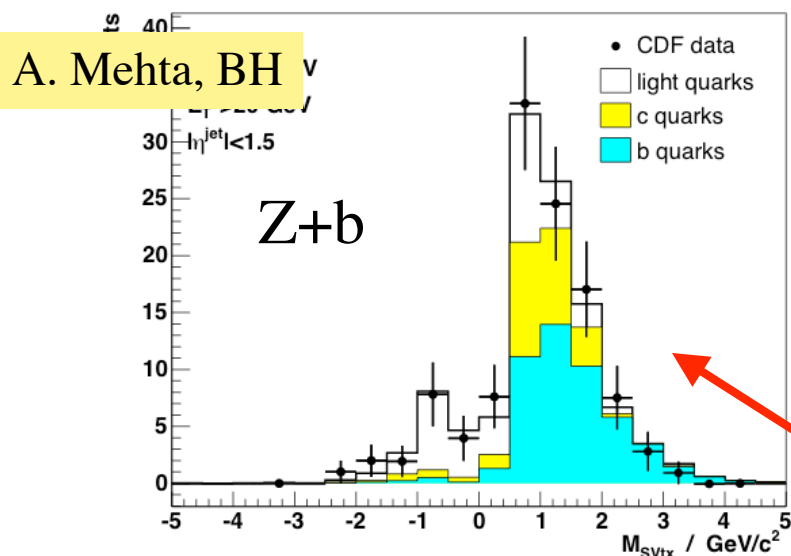
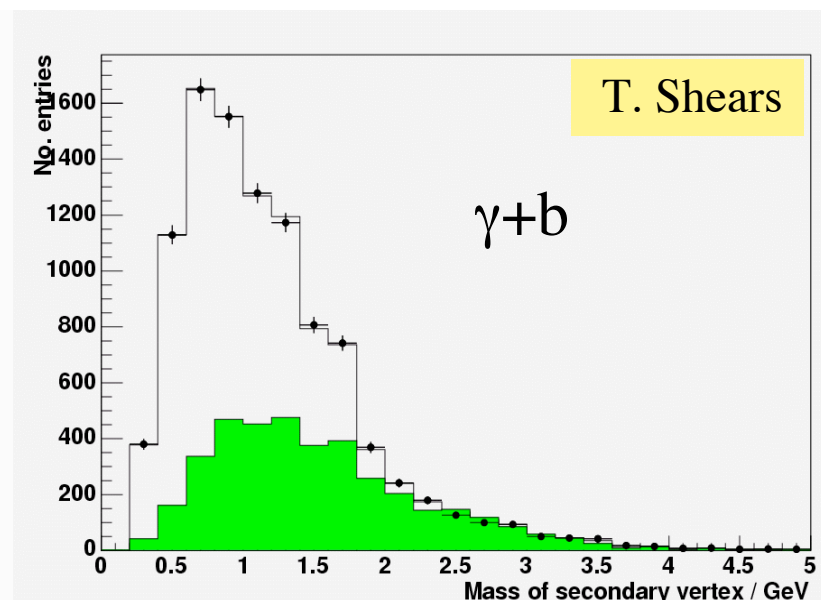
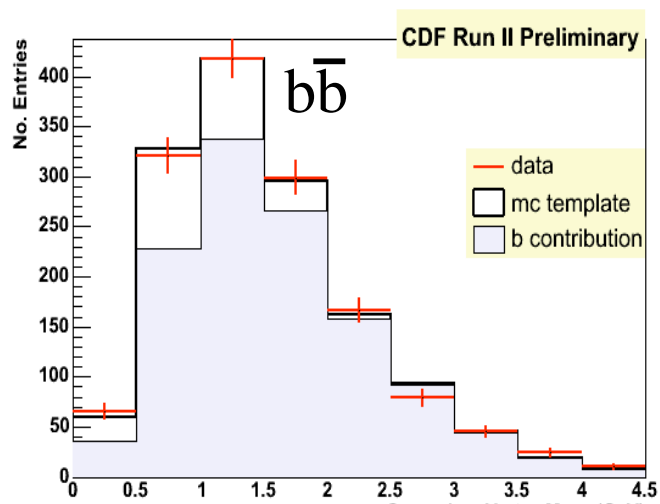
- Many measurements:
 - $B\bar{B}$ (Anant Gajjar)
 - Photon+b (T. Shears, R. McNulty)
 - $Z+b$ (A. Mehta, B.H.)
- Interesting subject:
 - Test of QCD
 - Sensitive to Higgs (ZH and WH)
 - Sensitive to New Physics (γb : GMSB SUSY, Technicolor)
- Experimental Technique:
 - Fit mass at secondary vertex
 - Extract fraction of b-jets

A. Gajjar, A. Mehta, R. McNulty, T. Shears



Fits to Vertex Mass

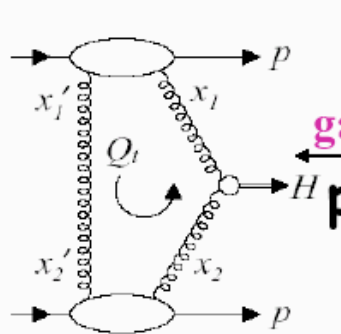
A. Gajjar, R. McNulty, T. Shears



- Measured cross sections of all
- All three processes generally good agreement with theory predictions

Draft in circulation

Exclusive Higgs Production



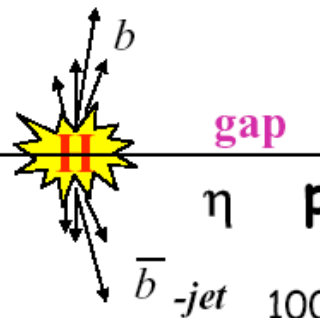
Exclusive production:

- $J_z=0$ suppression of $gg \rightarrow bb$ bkg
- Higgs mass via missing mass

$$M_H^2 = (p + \bar{p} - p' - \bar{p}')^2$$

$$\Delta M = O(1.0 - 2.0) \text{ GeV}$$

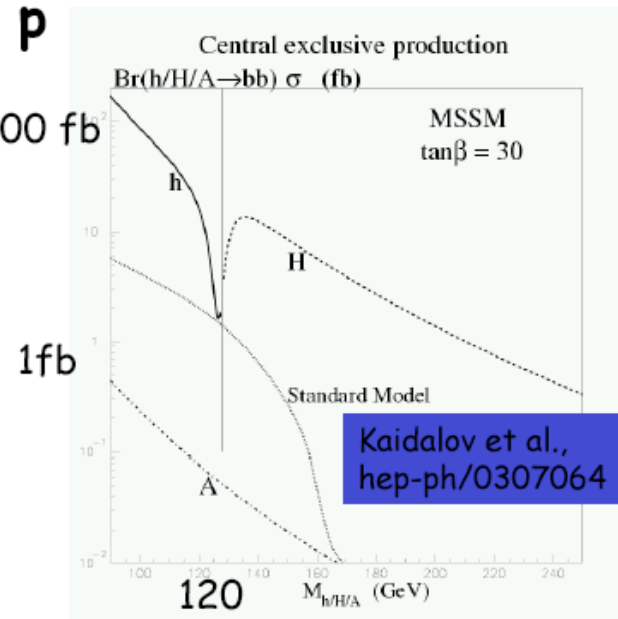
- CP structure of the Higgs from angular distribution of the protons



SM Higgs: (30 fb^{-1})

11 signal vs 12 bkg events

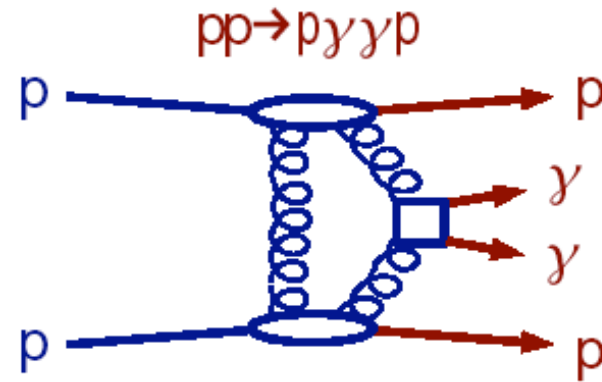
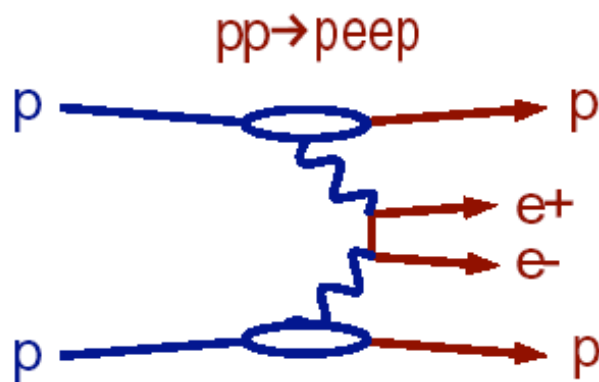
MSSM: $s \sim \times 10$ larger ($\tan\beta$)



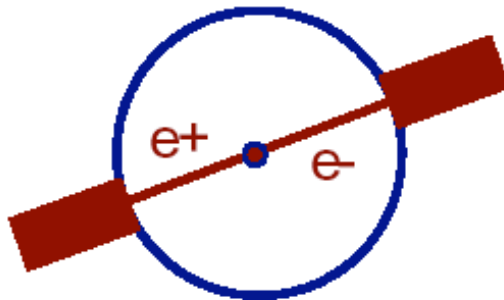
- FP420 Project:
 - Manchester, Glasgow, Durham, Bristol, Brunel, RAL, Cockcroft + many non-UK institutes
- Major uncertainty: is cross section calculation right? => test at CDF

Exclusive Diphoton/Dielectron

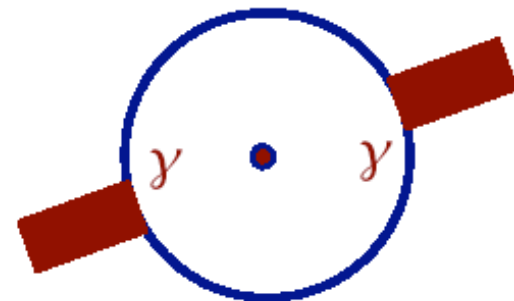
Exclusive Interaction: An in-elastic interaction in which both proton and (anti-)proton escape without dissociating.



Fundamentally different production mechanisms (QED vs. QCD), yet their detector signatures are *nearly identical*, and easily distinguishable.

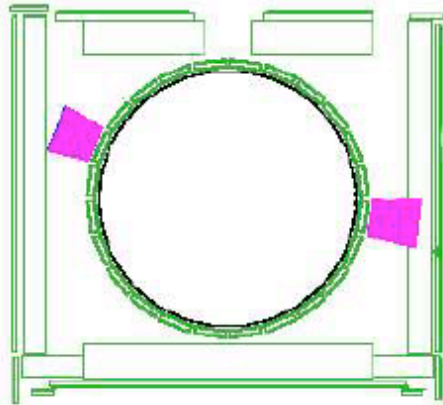


CDF $r\phi$ -view



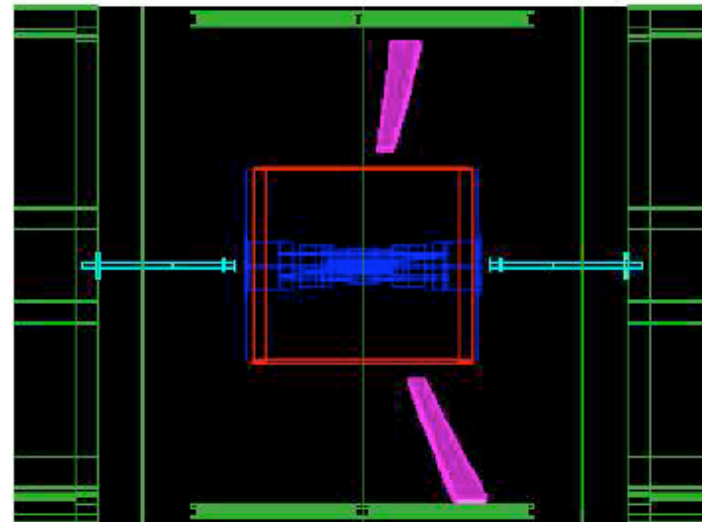
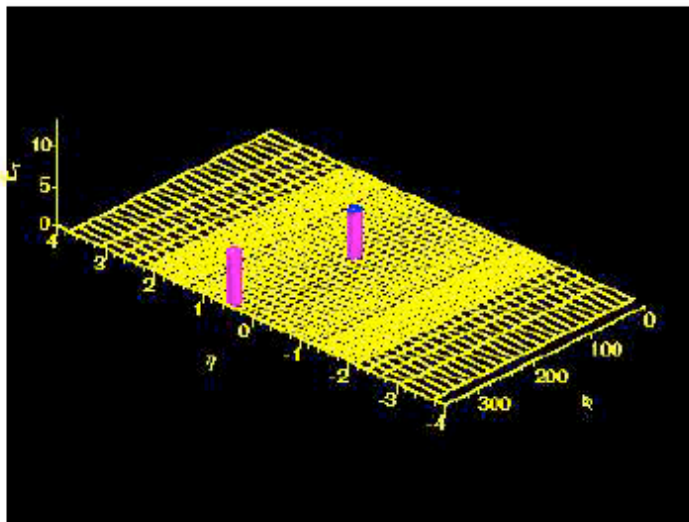
Candidate Event

3 $\gamma\gamma$ candidate events!

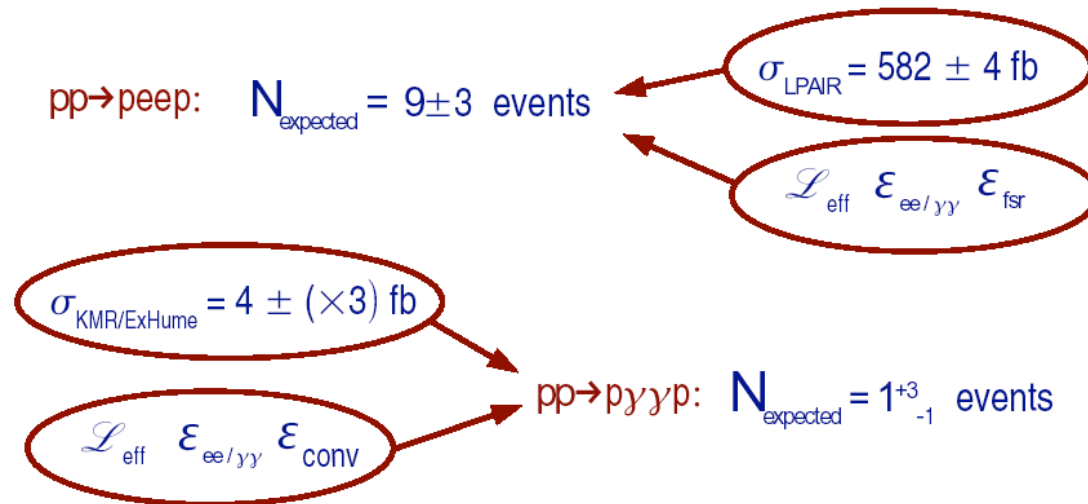


$$E_T(1) = 6.8 \text{ GeV}$$

$$E_T(2) = 5.9 \text{ GeV}$$



Result



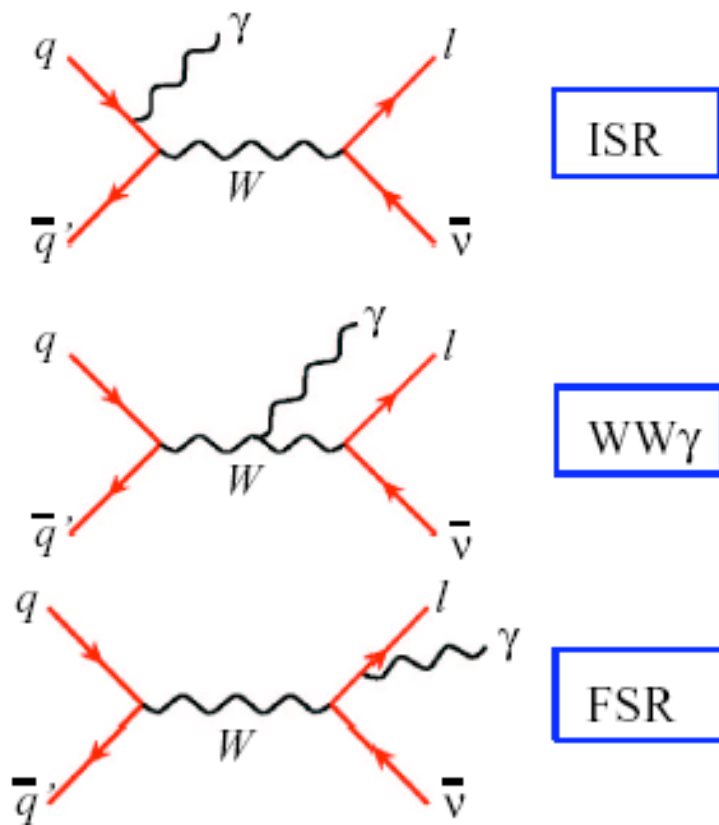
- No background estimate finished by that time
 - But already places upper limit on predictions
- Soon finished + more data
 - So far looks like prediction by Khoze, Martin, Ryskin, Stirling is right within factor 3

Electroweak Physics

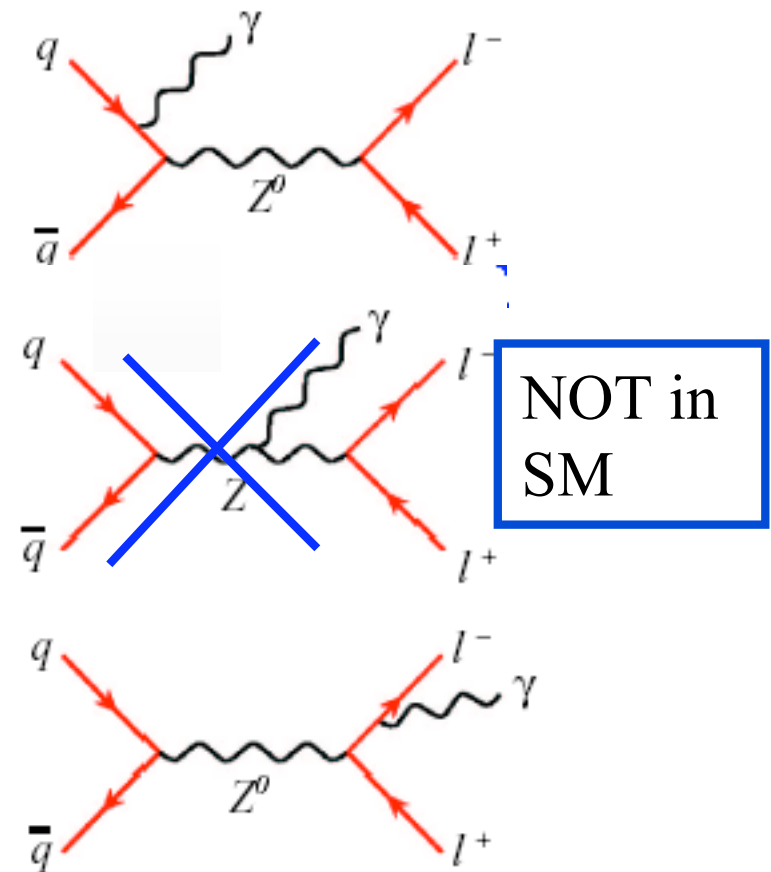
- Wgamma and Zgamma Production:
 - Helen Hayward, BH

$W\gamma$ and $Z\gamma$ Production

Tree-level diagram of
 $\bar{p}p \rightarrow W\gamma \rightarrow l\nu\gamma$



Tree-level diagram of
 $\bar{p}p \rightarrow Z\gamma \rightarrow ll\gamma$



These diagrams interfere and decay products are detected in the detector

W_γ and Z_γ Cross Sections

W_γ

	$e\nu\gamma$	$\mu\nu\gamma$
$W^+ \gamma$	126.8 ± 5.8	95.2 ± 4.9
$W^+ \text{jet BG}$	59.5 ± 18.1	27.6 ± 7.5
$W^+ \gamma (\text{tau})$	1.5 ± 0.2	2.3 ± 0.2
$Z^+ \gamma$	6.3 ± 0.3	17.4 ± 1.0
Total SM	194.1 ± 19.1	$142.4 \pm$
data	195	128 ¹²⁵
$\sigma^* \text{BR (pb)}$	19.4 ± 3.6	16.3 ± 2.9

Z_γ

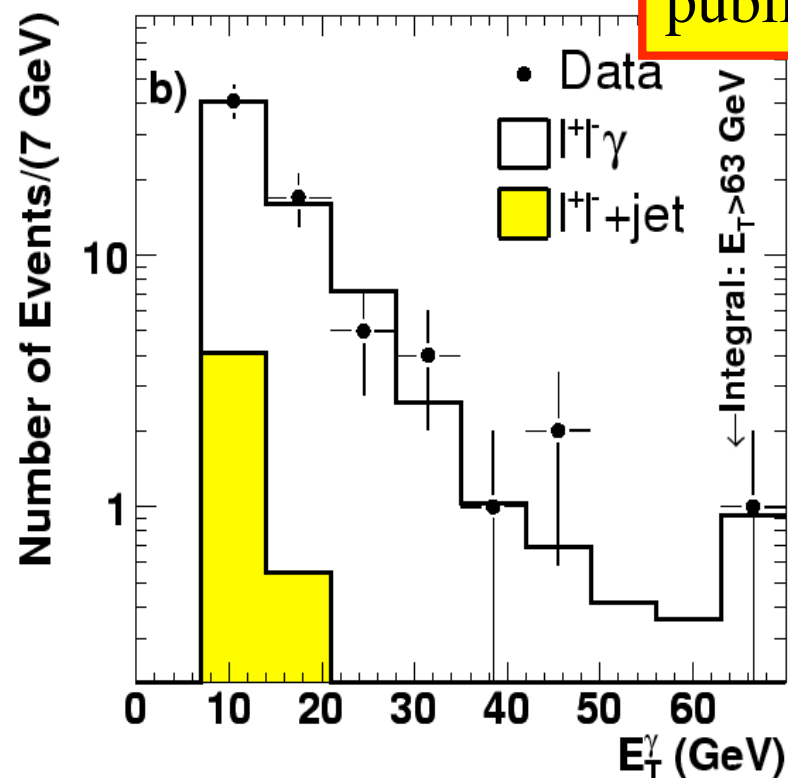
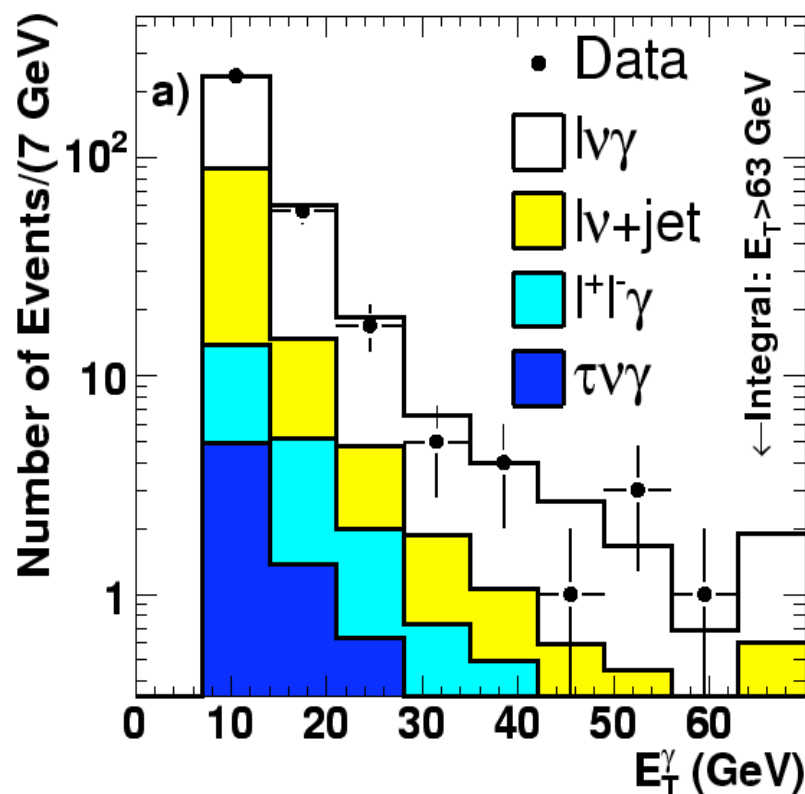
	$ee\gamma$	$\mu\mu\gamma$
$Z^+ \gamma$	31.3 ± 1.6	33.6 ± 1.5
$Z^+ \text{jet BG}$	2.8 ± 0.9	2.1 ± 0.7
Total SM	34.1 ± 1.8	35.7 ± 1.6
data	36	35
$\sigma^* \text{BR (pb)}$	4.8 ± 0.9	4.4 ± 0.8

$\sigma^* \text{BR} (W \rightarrow \ell \nu) = 18.1 \pm 3.1 \text{ pb}$
Theory: $19.3 \pm 1.4 \text{ pb}$

$\sigma^* \text{BR} (Z \rightarrow \ell \ell) = 4.6 \pm 0.6 \text{ pb}$
Theory: $4.5 \pm 0.3 \text{ pb}$

Photon E_T

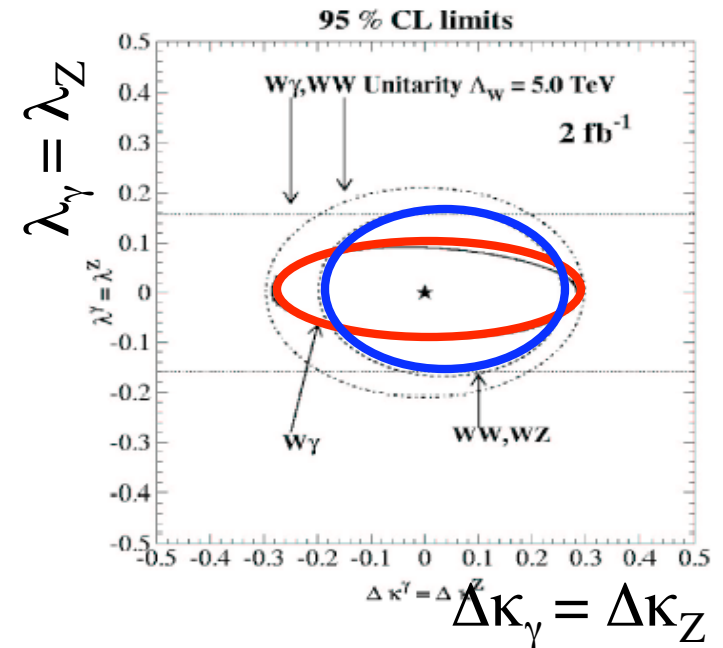
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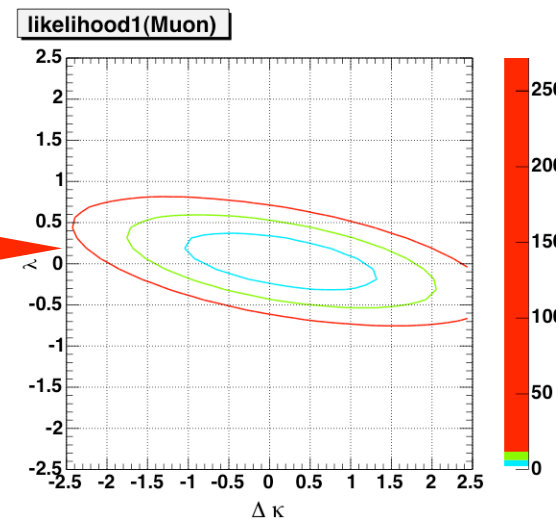
- Data agree well with SM
- Will be used to extract WW_γ and ZZ_γ couplings

WW γ Couplings: Future

- Tevatron constraints competitive with LEP with 2 fb⁻¹
 - Independent of assumptions on WWZ couplings
- Now doing this analysis with
 - Ai Nagano (Tsukuba)
 - Jianrong Deng, Al Goshaw, Tom Phillips (Duke)



Just muons with 200/pb



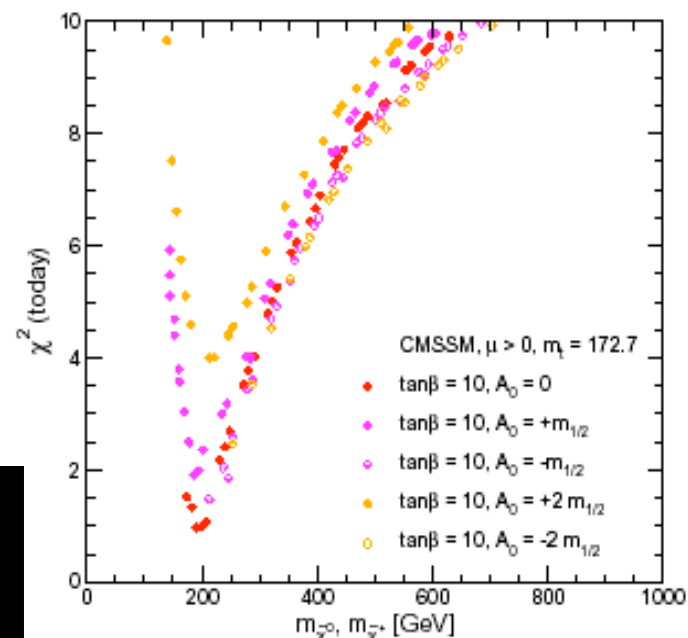
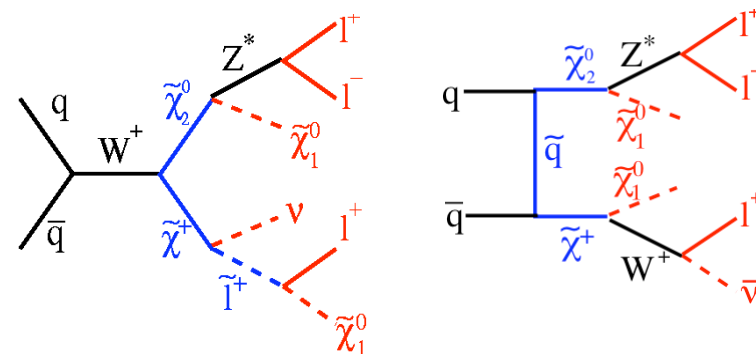
New physics

- **Trileptons:**
 - M. Griffith, G. Manca, BH
- **Extra Dimensions**
 - T. Berry, S.-M. Wynne

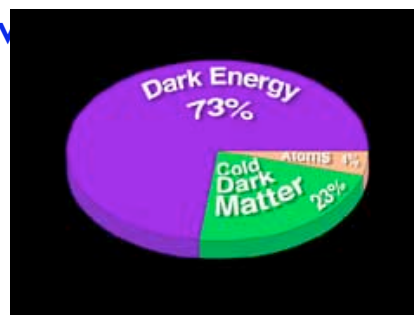
SUSY Trileptons

M. Griffith, G. Manca, BH

- “Golden” Trilepton Signature
 - Chargino-neutralino production
 - Low SM backgrounds
- 3 leptons and large Missing E_T :
 - Neutralino χ_1^0 is LSP
- Recent analysis of electroweak precision and WMAP data (J. Ellis, S. Heinemeyer, K. Olive, G. Weiglein: hep-ph/0411216)
 - Preference for “light SUSY”
 - Chargino mass around 200 GeV/c²
- Analysis from Martin and Giulia:
 - 3 l (l=e, μ)
 - ~~E_T~~ +topological cuts
 - Analysis most sensitive at low $\tan\beta$
 - BG expectation: 0.6 ± 0.08 ev
 - Observed: 0 events



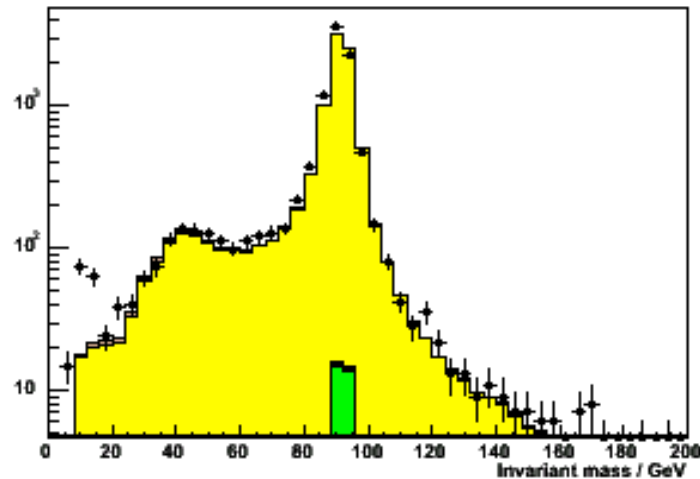
M(chargino)



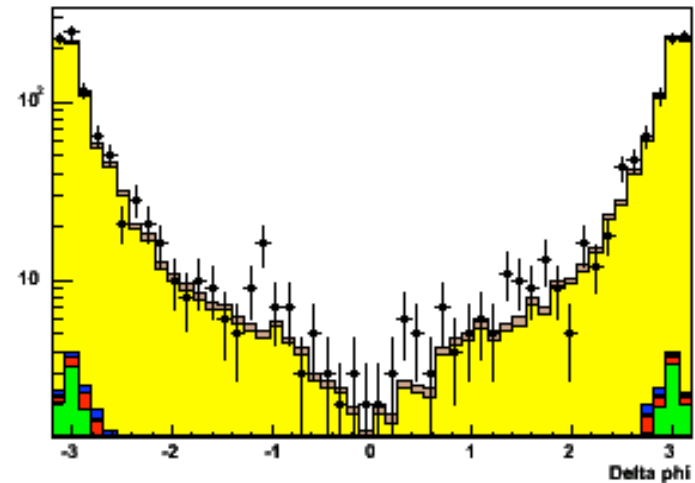
SUSY Trileptons

M. Griffith, G. Manca, BH

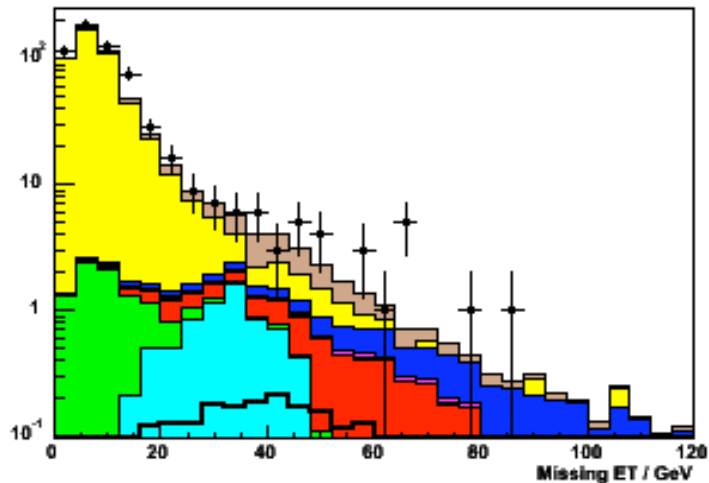
Invariant mass of leading leptons



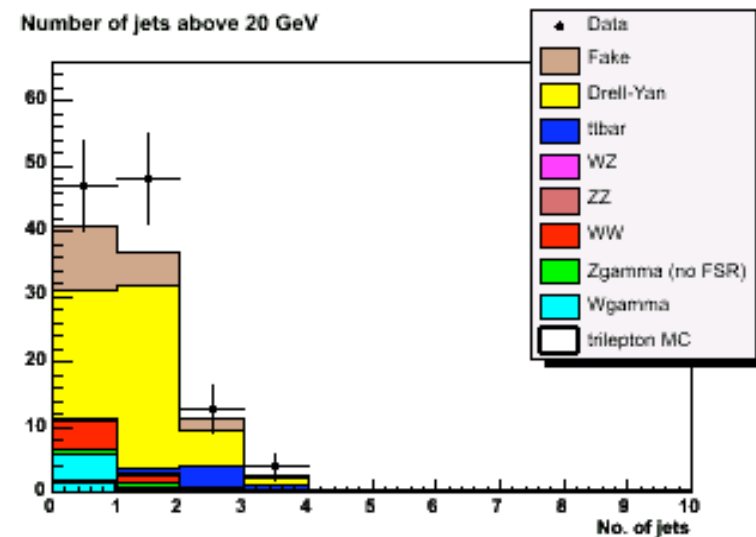
Delta phi between leading



Missing transverse energy



Number of jets above 20 GeV

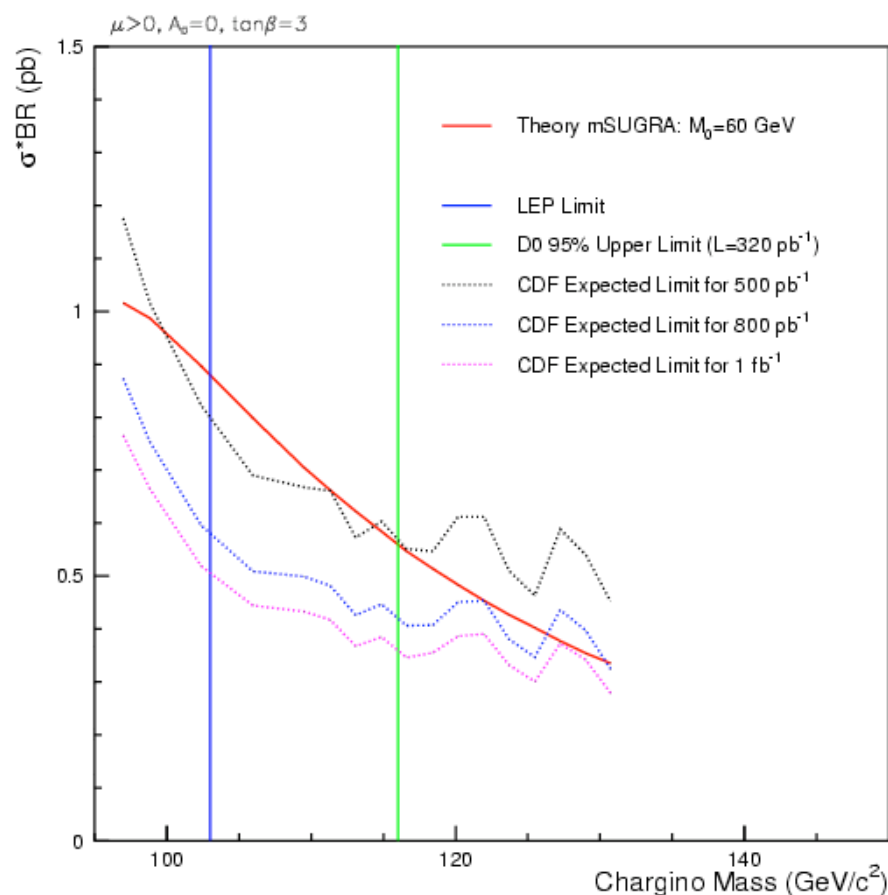


Good understanding of Backgrounds

Next Steps and Limiis

M. Griffith, G. Manca, BH

- Include 2005 data in analysis:
 - Double dataset: 750 pb^{-1}
- Combine with other analyses to maximise sensitivity
- Sensitive to charginos up to 130 GeV

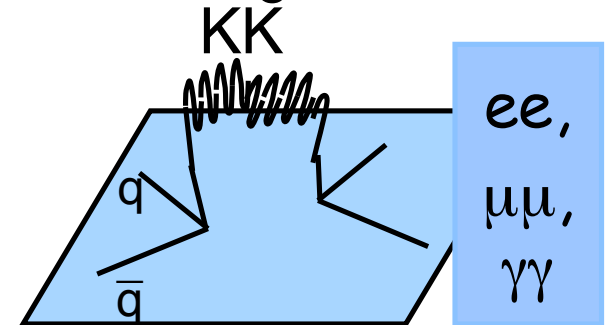


Extra Dimensions

- Attempt to solve hierarchy problem by introducing extra dimensions at TeV scale

- ADD-model:

- n ED's large: $100\mu\text{m}-1\text{fm}$
- $M_{\text{PL}}^2 \sim R^n M_S^{n+2}$ ($n=2-7$)
- Kaluza-Klein-tower of Gravitons \Rightarrow continuum
- Interfere with SM diagrams: $\lambda=\pm 1$ (Hewett)



- Randall Sundrum:

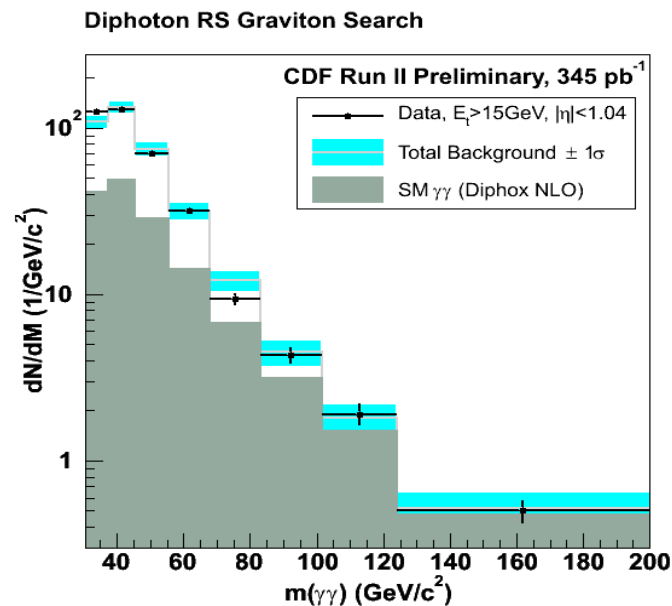
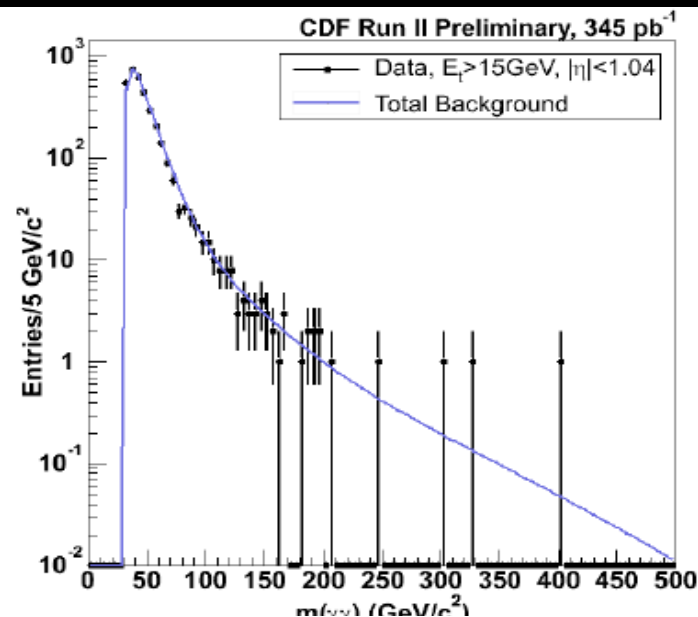
- Gravity propagates in single curved ED
- ED small $1/M_{\text{Pl}}=10^{-35}$ m
- Large spacing between KK-excitations
 \Rightarrow resolve resonances

- Signatures at Tevatron:

- Virtual exchange:
 - 2 leptons, photons, W 's, Z 's, etc.
 - $\text{BR}(G \rightarrow \gamma\gamma) = 2 \times \text{BR}(G \rightarrow \text{H})$

Randall–Sundrum Graviton

- Analysis:
 - 2 photon mass spectrum
 - Backgrounds:
 - direct diphoton production
 - Jets: $\pi^0 \rightarrow \gamma\gamma$
- Data consistent with background



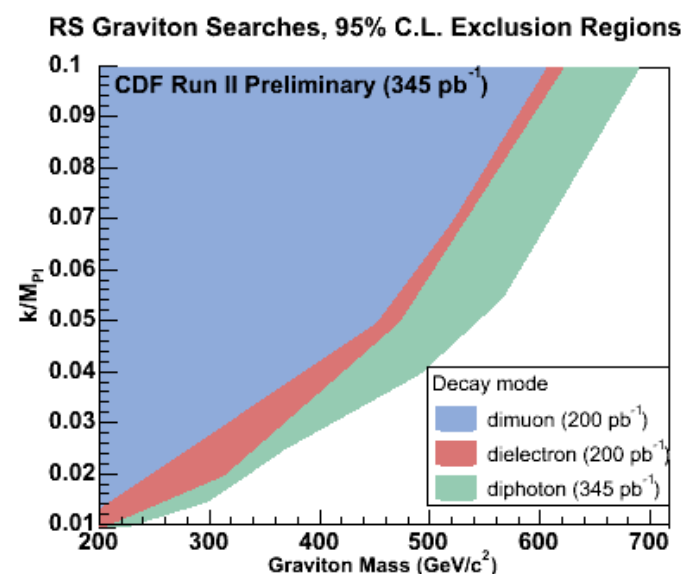
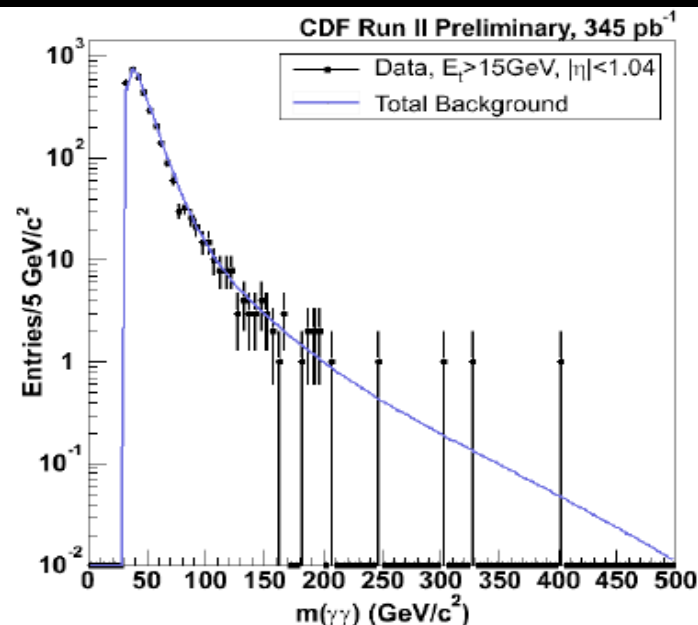
Randall–Sundrum Graviton

- Analysis:
 - 2 photon mass spectrum
 - Backgrounds:
 - direct diphoton production
 - Jets: $\pi^0 \rightarrow \gamma\gamma$

- Data consistent with background

- Relevant parameters:
 - Coupling: k/M_{Pl}
 - Mass of 1st KK-mode

Now updating with $>1 \text{ fb}^{-1}$



Future

- Rare b-decays and B_s oscillations:
 - Sinead, Rolf
- SM Higgs (ZH)
 - Nick Austin, A. Mehta, BH
- Finish off papers on other results:
 - Photon+b/c, bb, trileptons, ED
 - Possibly extend with more lumi but not said in RG

FTE's: last two years

Current Activities

Staff member	Average time p.a. (%)
PSL Booth (Ac)	35
M Houlden (Ac)	30
B Heinemann (Ac)	95
A Mehta (Ac)	55
TG Shears (Ac)	55
R Oldeman (Ac)	
T Berry (née Pratt) (Ph)	90
S Farrington (Ph)	100
BT King (PP)	25
R McNulty (visitor from UCD)	
A Gajjar (S)	100
M Griffiths (S)	100
H Hayward (S)	100
G Manca (S)	100

FTE's: Future

Staff member	Category	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12
Heinemann B	Ac/C	50	70	30	10	0	0
Houlden M A	Ac/C	5	20	10	0	0	0
Mehta A	Ac/C	20	30	10	0	0	0
Oldeman, R	Ac/C	10	20	0	0	0	0
Shears T G	Ac/C	20	20	10	0	0	0
Farrington S	Ph/R	40	70	60	40	10	0
King B T	PP/C	5	0	0	0	0	0

Nicholas Austin

Ronan McNulty (visitor from UCD)

Severe ramp-down due ATLAS and LHCb coming online